Neutrino Factory Studies in the U.K.

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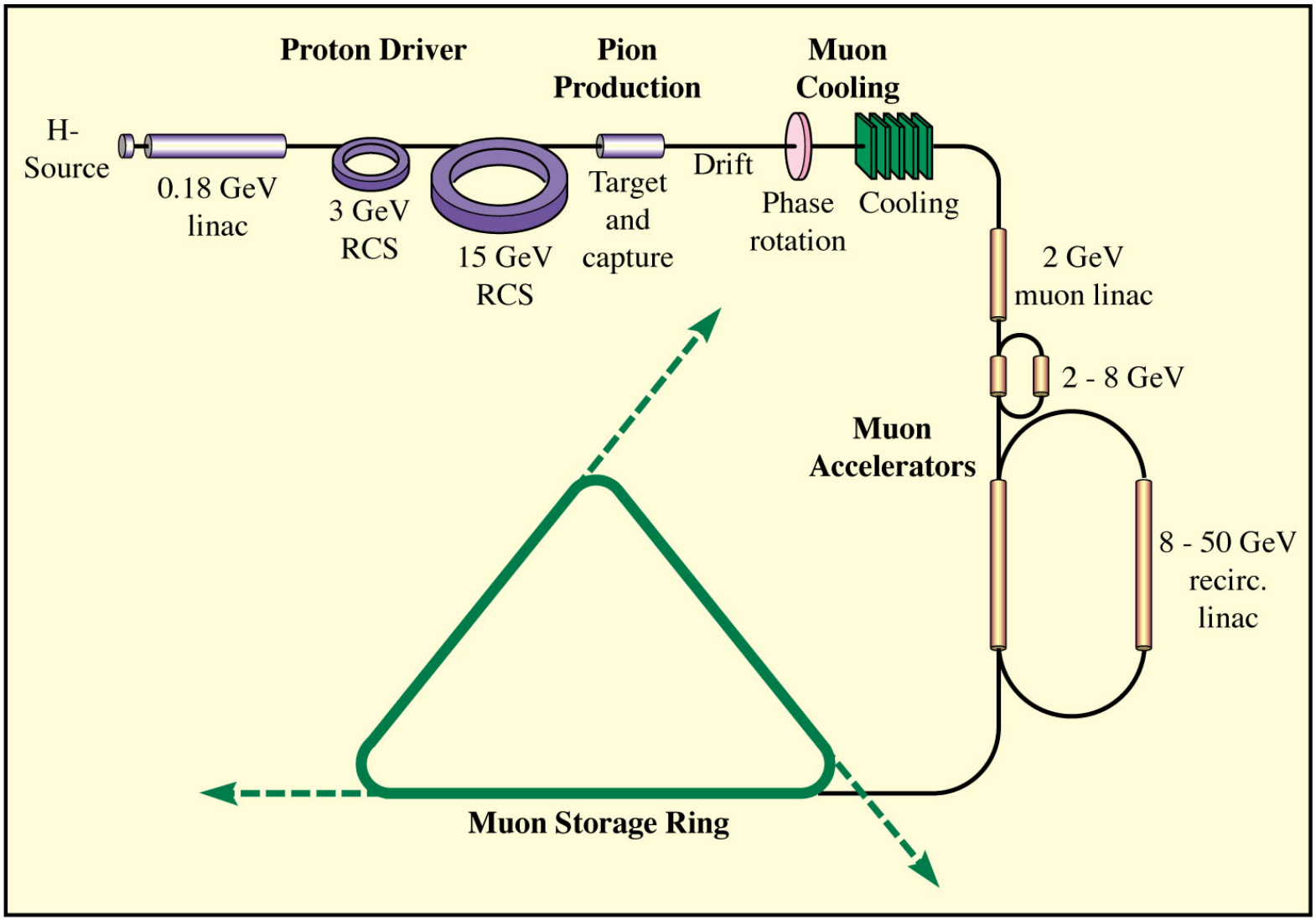
Outline

NF Accelerator Studies in the U.K.

- ASTeC-funded generic proton accelerator programme
- EU FP6 ESGARD/CARE HIPPI package
  - Devoted to the study of high intensity pulsed proton/ion linacs up to energies of 200 MeV
  - Collaboration between CCLRC, CERN, FZJ, CEA, CNRS (IN2P3, LPSC), GSI, IAP-Frankfurt, INFN-Milan
- PPARC-funded U.K. Neutrino Factory programme
  - WP1: Conceptual design studies
  - WP2: Proton Driver Front-end Test Stand (FETS) accelerator R&D
  - WP3: Target studies
  - WP4: Future design studies
- Muon Ionisation Cooling Experiment

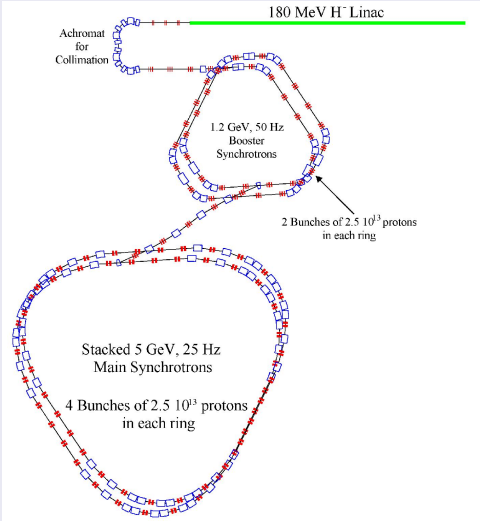
U.K. Neutrino Factory Scenario



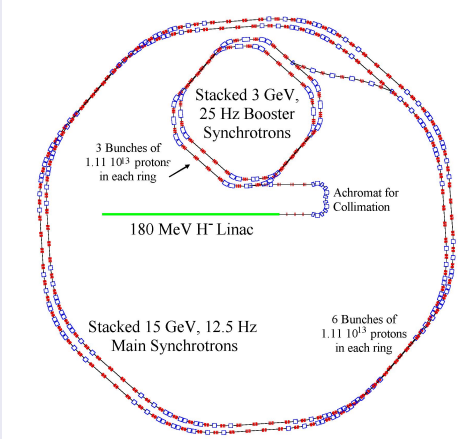
Neutrino Factory at RAL

Proton Driver Designs: Synchrotron-Based

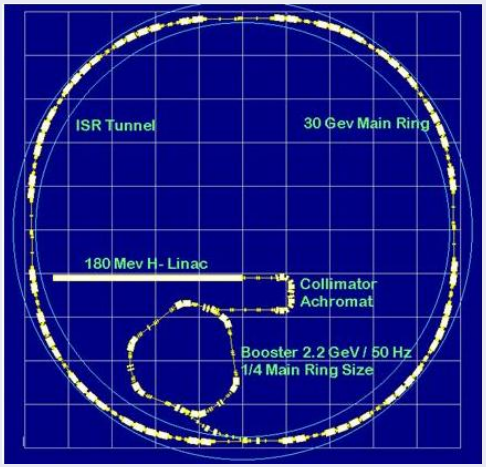
5 GeV, 50 Hz



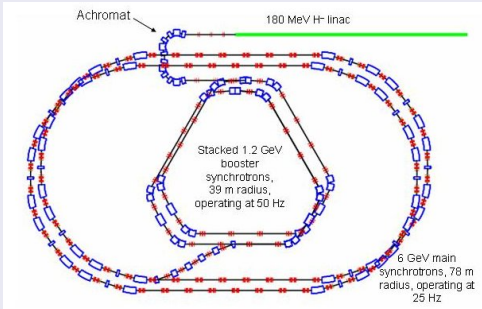
15 GeV, 25 Hz



30 GeV, 8 Hz



6–8 GeV, 50 Hz



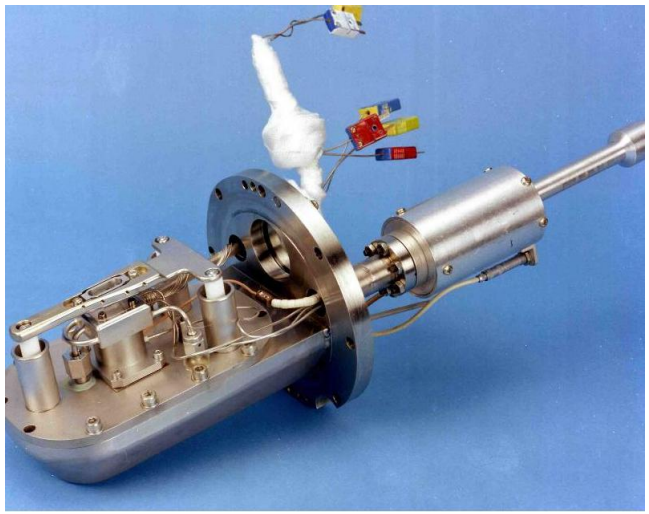
Based on pairs of rings, doubling radius, halving frequency etc to reduce space charge and magnet ramping problems. Boosters for proton accumulation; main rings for $\sim$1 ns bunch compression.

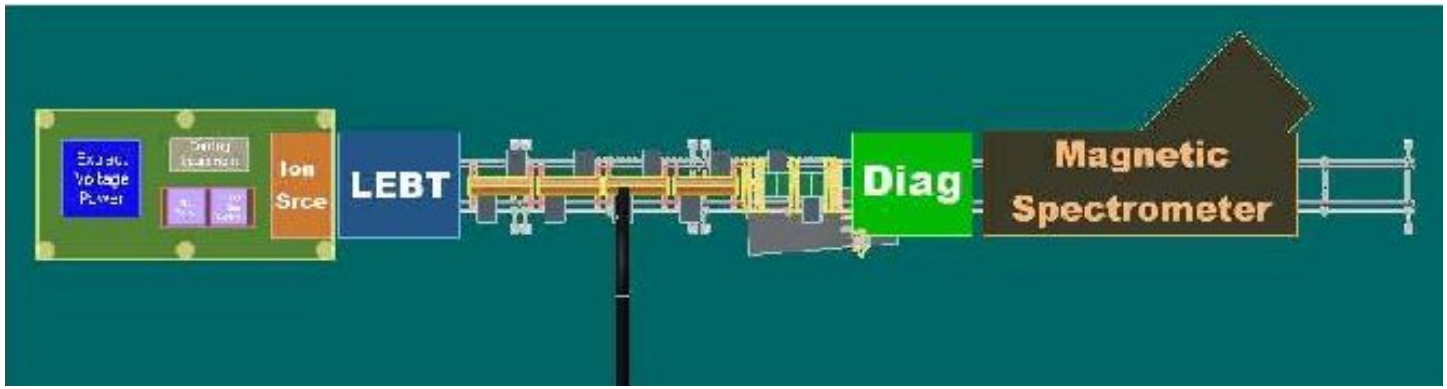
15 GeV and 30 GeV rings designed to fit in CERN's ISR tunnel.

6–8 GeV model could be a phased upgrade of ISIS for a dual purpose neutron/neutrino facility.

Experimental Programme: FETS

- Ion source
- Low Energy Beam Transport (LEBT)
- Radio Frequency Quadrupole (RFQ)
- Medium Energy Beam Transport (MEBT) with beam chopper
- Diagnostics

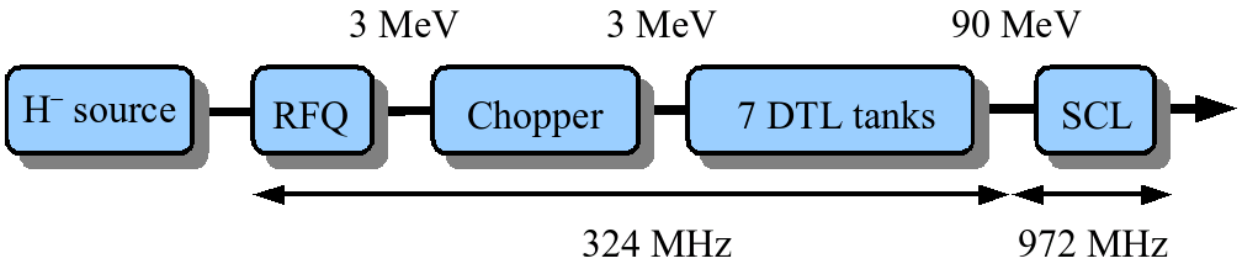




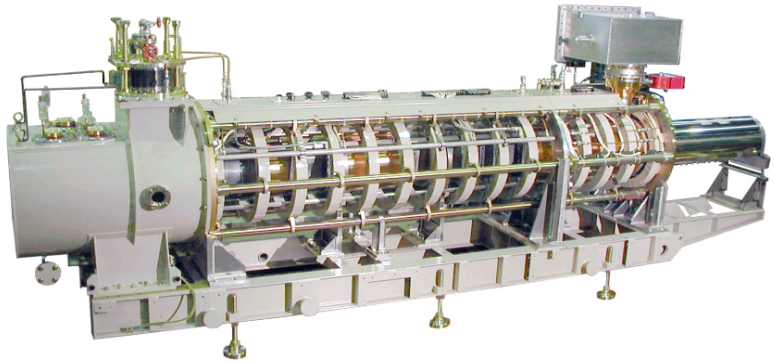
Plan view of FETS; courtesy P. Savage

180 MeV H^- Linac

- Forms the basis for all RAL proton driver designs
- Developed in close collaboration with CERN's Linac4 project and as part of HIPPI WP2.



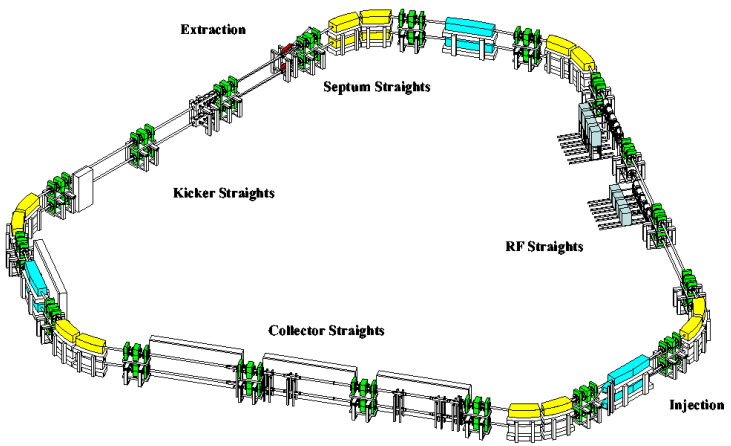
- J-Parc frequency of 324 MHz has been chosen. Toshiba klystrons would allow a triple frequency jump at ∼90 MeV.



- Linac could be used for an upgrade to the ISIS spallation neutron source and included in future development into a 4 MW proton driver.

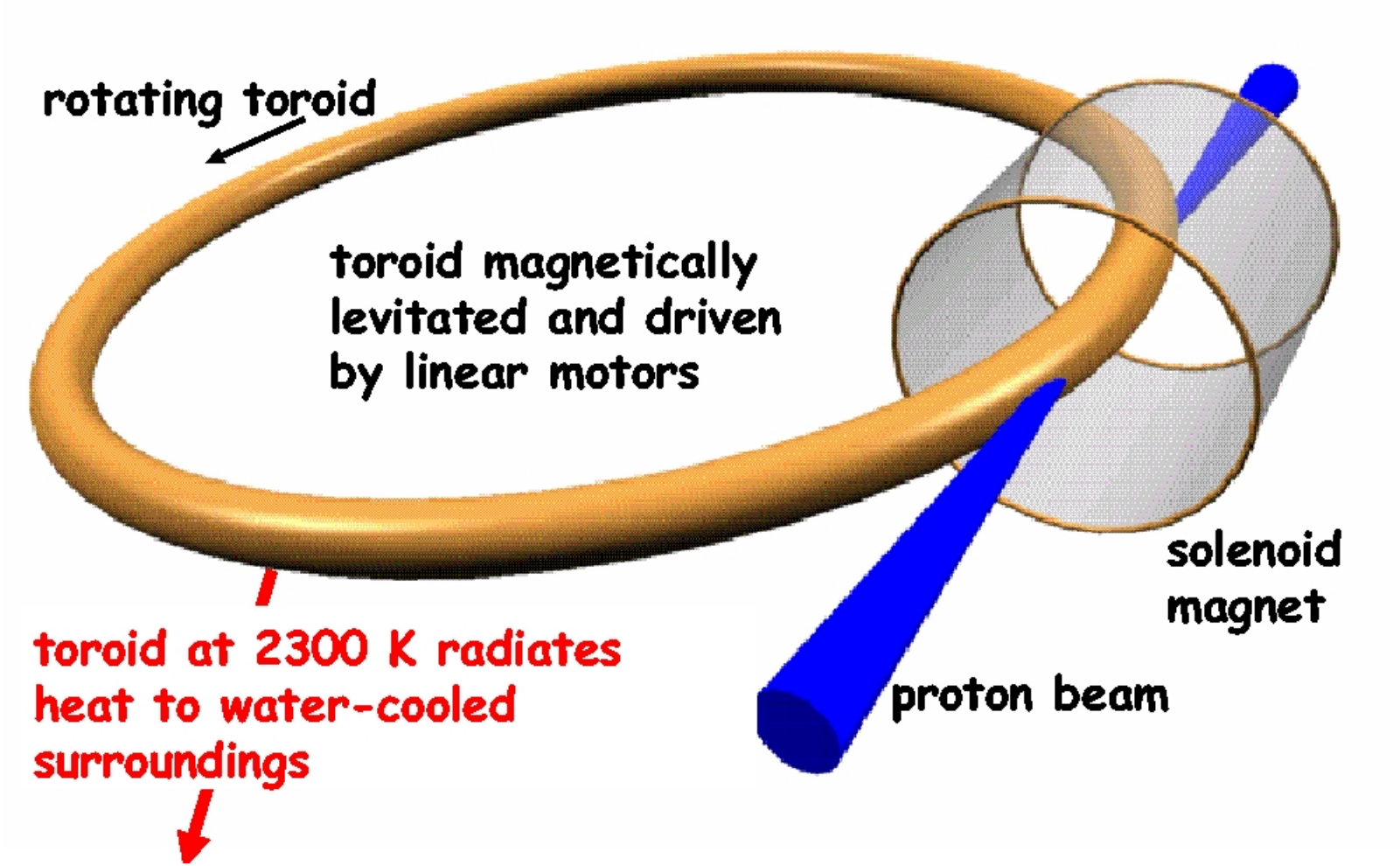
Additional Proton Driver Studies

- Linac code development (IMPACT): error analysis and halo formation (EU/HIPPI)
- Code development for rings, in particular for a better understanding of injection and early stages of acceleration.

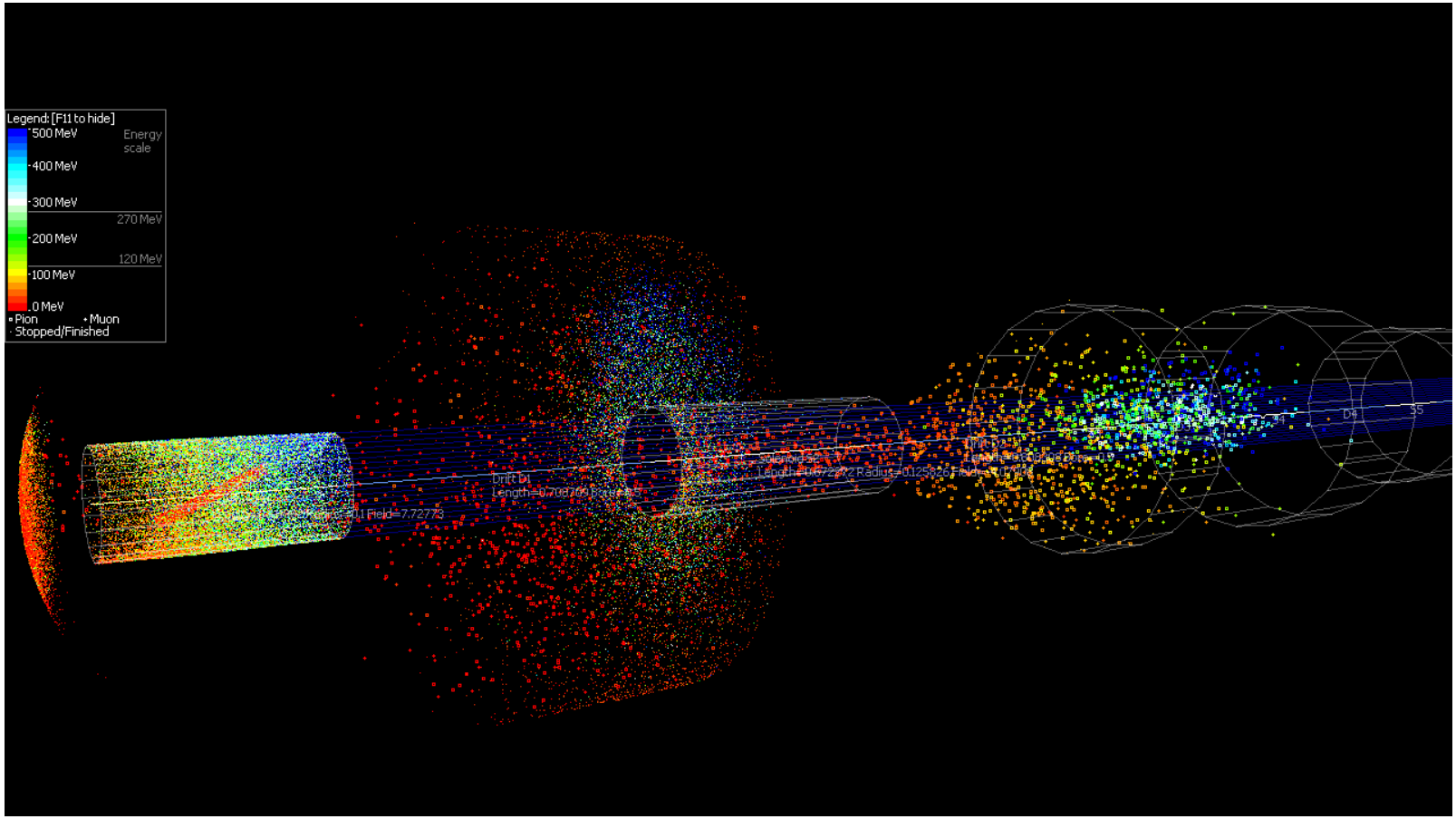


- General beam dynamics studies and comparison with measurement.
- Instability analysis in rings, in particular a theoretical study of *electron cloud effects* in high intensity proton machines allied to an experimental programme at RAL.

Target Studies

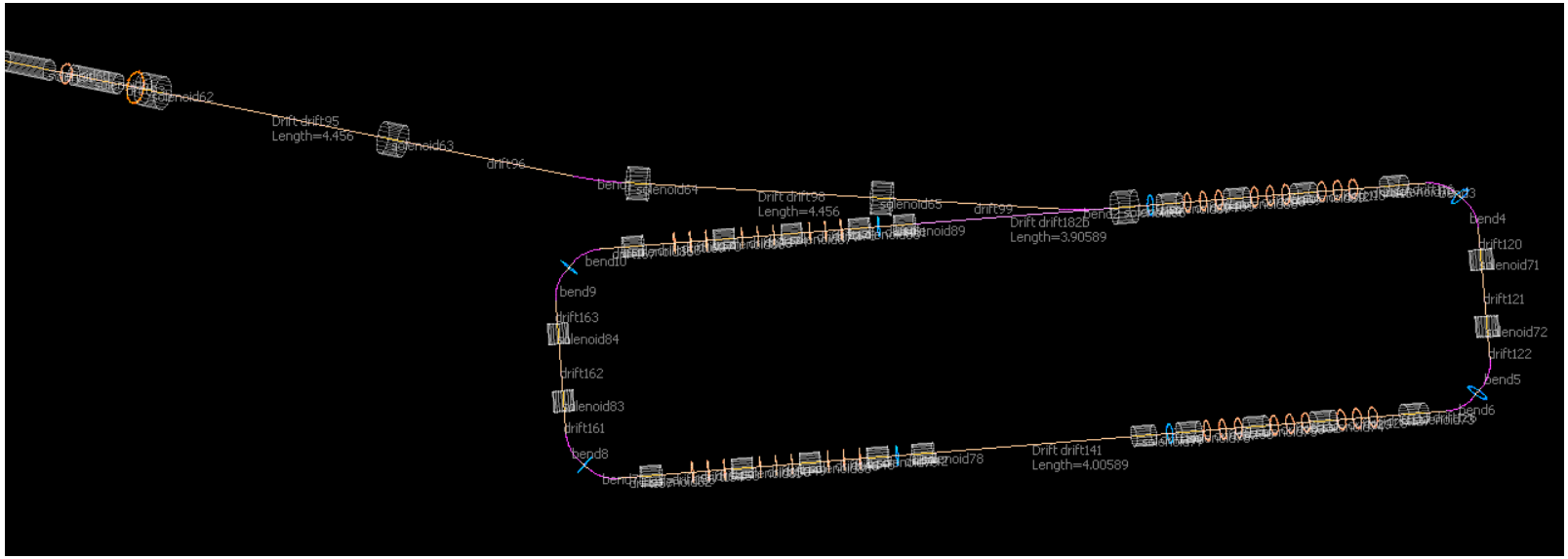


Pion Capture and Muon Decay



- Solenoid capture channel, intensively optimised via international collaboration.
- Channel efficiency: 2.25% μ^+/π^+ at 2.2 GeV

Muon Cooling

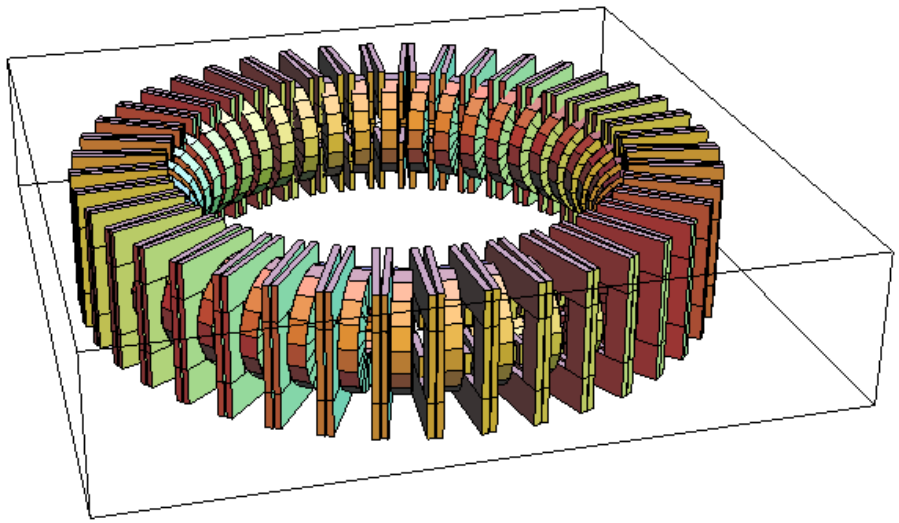


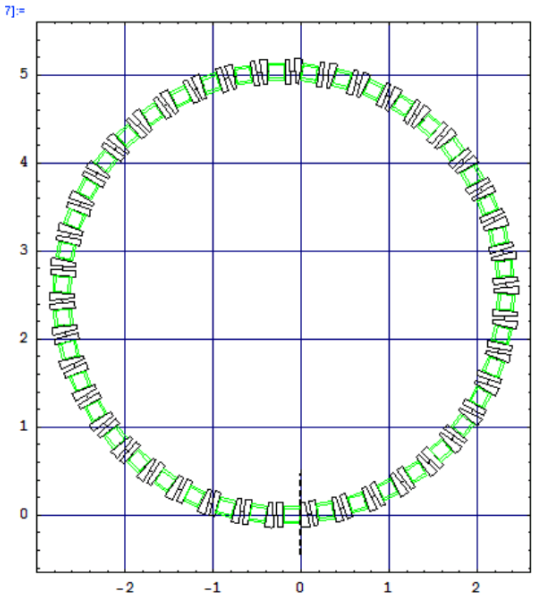
- Cooling ring design presented at NUFACT'03 (London)
- New, advanced 3D modelling code under development
- First simulation results to be presented at PAC'05 in Knoxville.

Muon Acceleration FFAG

FFAG Designs

- Isochronous non-scaling FFAG for muon acceleration 8–20 GeV
- Electron FFAG model (isochronous), ∼20 m circumference
- FFAG for a 5 MW proton driver



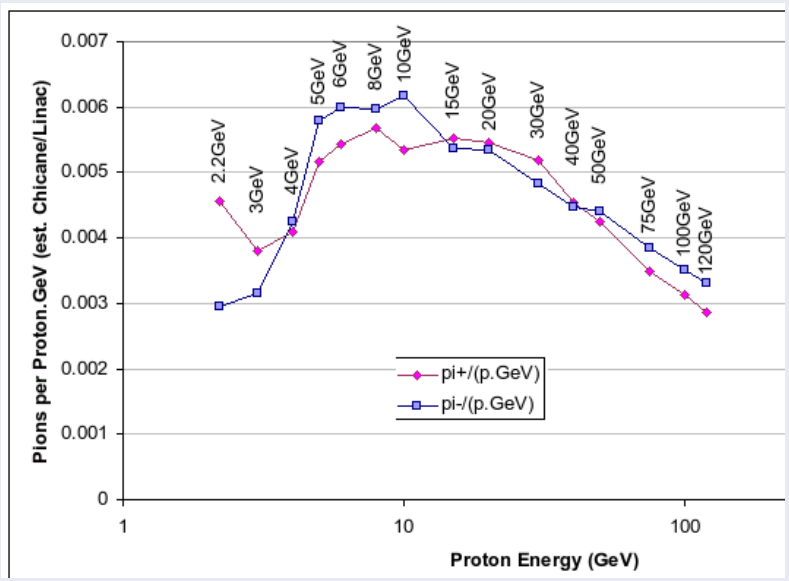


Proposals for an electron FFAG using the ERLP linac at Daresbury have been submitted to the EU. International collaboration: UK, CERN, CEA, BNL, FNAL, TRIUMF, KEK, Rostock, Uppsala, Univ. Kyoto.

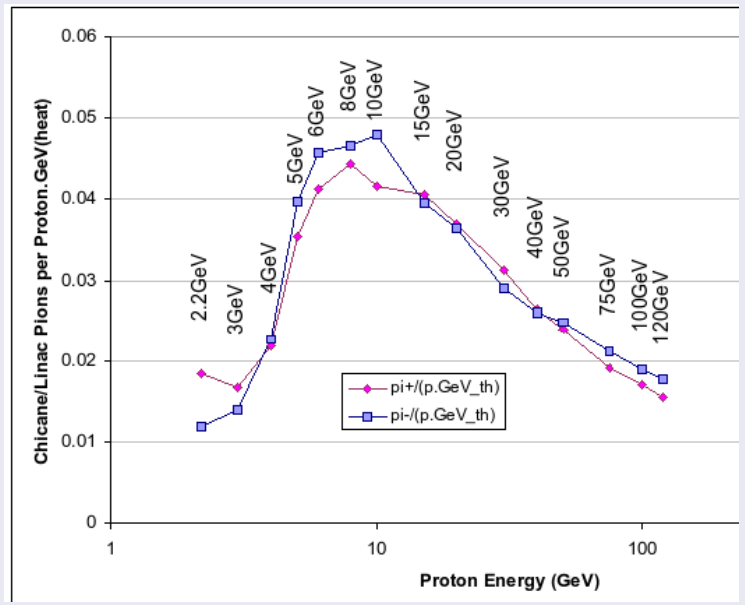
Proton Driver Energy Choice

- MARS.15 investigation of distribution of pions emanating from target for a range of proton driver energies 2–50 GeV.
- Examine effects of changing target radius, topology etc.
- Look at muon transmission per proton through capture channel for different driver energies.

Scaled to Driver GeV



Scaled to Rod Heating



Summary

- Generic Front-end Test Stand (FETS) is developing at RAL in collaboration with several U.K. universities and support from ASTeC, EU/FP6 and UK/PPARC.
- Theoretical design of 180 MeV linac continues in parallel.
- Other aspects of proton driver directed mainly at synchrotron modelling, e-cloud studies, and a machine physics programme on ISIS is proposed.
- Progress is being made on the choice of proton driver energy based on a balance between target requirements and accelerator capabilities.
- Remaining U.K. NF accelerator work is concentrated on pion capture/muon decay and cooling channels, muon acceleration using FFAGs.
- Plans for a (non-scaling) test electron FFAG model at Daresbury Laboratory have been submitted to the EU.

Comment

- The target is arguably the most difficult part of the whole NF facility (*c.f.* ESS experience).
- The proton driver needs to take account of target limitations (shock, heating) in its choice of energy and the length and structure of the bunch train.
- The driver energy and target geometry determine the pion/muon distribution and affect the design of the capture channel.
- The need is to maximise the number of muons entering the accelerating system.
- Particularly close collaboration is therefore needed between driver, target and muon front-end working groups to produce the optimum operable system overall. This will inevitably mean a compromise between all regions of study.